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ABSTRACT

This fastback examines the theory and practice of constructivist teaching and suggests how teachers can decide what form of constructivist teaching they might want to use. Constructivist teaching theory is explored under the headings "knowledge" and "humans." According to constructivist theory, knowledge is constructed by humans, it is conjectural and fallible, and it grows through exposure. Humans have a built-in aversion to disorder and have internal knowledge structures that guide perceptions, understanding, and action. Five elements of one conception of constructivist teaching practice include; activating prior knowledge, acquiring knowledge, understanding knowledge, using knowledge, and reflecting knowledge. The four types of constructivist teaching that emerge from these five elements are application, discovery, extension, and invention. Examples of these types are given. The next section focuses on beliefs and their importance in deciding about constructivist teaching and which forms to use. In the last sections, threats to implementation and the future of constructivist teaching are discussed. (Contains 14 references.) (ND)

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Constructivist Teaching

John A. Zahorik

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Constructivist Teaching

by
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Table of Contents

The Emergence of Constructivist Teaching 7

Constructivist Teaching Theory 10

Knowledge 11

Humans 12

Constructivist Teaching Practice 14

Five Basic Elements 14

Four Types of Constructivist Teaching 22

Constructing Constructivist Teaching 33

Threats to Implementing Constructivist Teaching 37

Constructivist Teaching and the Future 40

References 41

The Emergence of Constructivist Teaching

Where there is much desire to learn, there of necessity will be much arguing, much writing, many opinions; for opinion in good men is but knowledge in the making.

— John Milton, *Areopagitica*, 1644

Deciding how to teach is a problem that all teachers face throughout their careers. Ideas about how to teach often come from formal research and theory, but they also come from informal sources, such as personal experimentation and reflection, observation of and dialogue with colleagues, and memories of one's own teachers.

In the 1970s and 1980s research in particular was a dominant source for ideas about how to teach. It produced direct instruction. This type of teaching, which teachers everywhere were urged to adopt, is based on studies by Stallings and Kaskowitz (1974), Good and Grouws (1979), and others, as well as on the research-based framework developed by Hunter (1982). It consists of several well-known elements: readiness, instruction, checking, practice, and review. The research found that learning, as evidenced by standardized achievement test score gains, occurred when teachers got students' attention at the beginning of the lesson; directly instructed them concerning the content or skills to be learned; checked to determine if the content or skills were acquired and, if not, retaught them; provided practice activities so that the learning became internalized; and provided periodic reviews.

Although direct instruction is a supportable way to teach and all teachers undoubtedly use direct instruction to some degree in their teaching, it has serious limitations. Direct instruction is effective when the goal of instruction is to have students acquire and reproduce factual knowledge and well-defined skills. It can be a successful method when teaching adding and subtracting, word syllabication, and map reading in elementary classrooms and in teaching basic knowledge and processes in any subject in middle and secondary classrooms. As long as reproduction is the objective, direct instruction is effective and efficient. When the goal of instruction is more than reproduction, when the goal is understanding, thinking, and creation, direct instruction is of limited value.

Having foundational knowledge and skills in the traditional disciplines of language, mathematics, science, social studies, and the arts is of critical importance for everyone; but it is sufficient neither for us as individuals nor for us as a society. To be able only to reproduce what has been presented to us is to ignore the enormous potential that humans have for being self-directed, creative, and productive. As more and more reproductive tasks are being done by computers and other machines, human minds must be put to the more important tasks of which they are capable. In addition to greater personal fulfillment, focusing on more than the reproduction of basic knowledge and skills has economic and social benefits for our society. To be competitive in foreign markets, reports such as *America 2000* remind us, we need a workforce that not only is proficient in basic skills but also can think, apply knowledge, and solve problems.

Constructivist teaching emphasizes thinking, understanding, and self-control over behavior but does not neglect basic skills and knowledge. This type of teaching, which has emerged in recent years, is called constructivist teaching because it is based on the notion that humans are constructors of their own knowledge, rather than reproducers of someone else's knowledge.

The purpose of this fastback is to examine the theory and practice of constructivist teaching and to suggest how teachers can decide what form of constructivist teaching they might want to use. In the next section the theory undergirding constructivist teaching is explored. This is followed by a section that details the teaching elements and basic types of constructivist teaching and another section that focuses on beliefs and their importance in deciding about constructivist teaching. In the last sections, threats to implementation are explored and the future of constructivist teaching is discussed.

9

Constructivist Teaching Theory

The dominant learning theory since the turn of the century has been behaviorism. The various forms of behaviorism, such as operant conditioning, respondent conditioning, and modeling, all share the view that learning is a response by the learner to various stimuli present in the environment. In this stimulus-response view, usually represented as the S-R unit, the learner is a passive reactor who is shaped by associating behaviors with their consequences. The learner is more or less helpless. Whatever he or she learns and does is a function of his or her environment.

Psychologists who support the S-R notion have examined how S-R units are acquired, retained, linked, and transferred, usually in regard to simple tasks and often involving animals.

Although adequate for explaining the learning of many simple behaviors, behaviorist learning theory cannot explain the learning of more complex behavior very well, perhaps because behaviorists have ignored the mental processes that mediate the S-R unit. Between the stimulus and the response is a mind. Humans do not blindly react to stimuli. They are perceiving, thinking beings with insights, reasoning power, and the ability to make decisions. Humans can and do select the stimuli to which they respond and choose a response that makes sense to them. A unit that more adequately represents the learning process is the S-MIND-R unit.

The realization that something more was needed to explain the rational, logical, cognitive process that occurs between stimuli and re-

sponses gave birth to cognitive psychology, which in turn has in large measure provided the theoretical basis for constructivist teaching. Of the cognitive theorists, one major figure has been Piaget (1971). He suggested that cognitive functioning involves the complementary processes of assimilation and accommodation. Assimilation is a shaping process in which new experiences are received through existing knowledge structures, while accommodation is reshaping the existing knowledge structures to accept the new experience. The whole process, which is driven by a desire to achieve equilibrium or balance between personal constructions and new experiences, results in a cognitive structure that is more integrated or accepts more ideas and that is more differentiated or contains more substructures.

This conception of learning spawned many related conceptions, such as Rummelhart and Norman's (1978). They posited three kinds of cognitive processing: 1) accretion, or the encoding of new information in terms of the existing structure; 2) restructuring, or the process of creating new structures; and 3) tuning, or the gradual modification of existing structures as a result of using them. In addition to cognitive psychology, brain-function research and postpositivist philosophy serve to support constructivist teaching. A synthesis of work from these areas yields the framework of ideas, or the theory, for constructivist teaching. These ideas concern conceptions of knowledge and humans.

Knowledge

Knowledge is constructed by humans. Knowledge is not a set of facts, concepts, or laws waiting to be discovered. It is not something that exists independent of a knower. Humans create or construct knowledge as they attempt to bring meaning to their experience. Everything that we know, we have made. Although there may be a reality that our constructions represent, this correspondence is not knowable. All that humans can know is that their constructions are compatible with other constructions they have made or know.

Knowledge is conjectural and fallible. Since knowledge is a construction of humans and humans are constantly undergoing new experiences, knowledge can never be stable. The understandings that we invent are always tentative and incomplete. Even the understandings that we have that appear to be immutable are not. It was not very long ago that the periodic table contained 83 elements, the solar system had eight planets, the angles of a triangle equaled 180°, and dinosaurs were cold-blooded animals. Although the understandings that we invent are imperfect, it does not mean that they are equally imperfect. While still being conjectural and fallible, some constructions fit better with other constructions.

Knowledge grows through exposure. Understanding becomes deeper and stronger if one tests it against new encounters. These encounters can be experiences that individuals have with objects and events. But because understandings can be encoded in language, they can be social encounters. Individuals can share their knowledge and get feedback from others. Through these pooled and critiqued understandings, knowledge grows. The disciplines of history, law, botany, mathematics, anthropology, and others are agreed-on social constructions. They have undergone and continually undergo the elimination, alteration, and strengthening of meanings through collegial sharing. Knowledge is, as Leinhardt (1992) suggests, both individual and community property.

Humans

Humans have a built-in aversion to disorder. Understanding, or making meaning, is an unavoidable consequence of being human and driven by the survival instinct. As humans, we constantly are monitoring our environment. Those occurrences that are novel are made to fit one's existing order, or one's existing meanings are reordered in an effort to understand and take action to avoid harm. Making sense of things means relating them to one's existing organization of ideas.

Humans have internal knowledge structures that guide perception, understanding, and action. All humans possess networks of meanings that are constantly being revised. These meanings, which are the result of past experiences, both physical and social, guide the perception of new experiences. That is, we see new things in relation to our present knowledge structures. The structures shape the perception, but the perception also feeds back and shapes the structure. It is the developing internal knowledge structure that then directs behavior.

To accept the notion that internal knowledge structures guide perception is to accept the belief that a person always has a knowledge structure that can bring meaning to a situation. If we were asked to explain the transfer function of Pascal programming, many of us would be convinced that we had no previous knowledge on which to draw; but in the hands of a skillful teacher, we would see that we had existing knowledge structures to bring to the task. They may be embryonic, incomplete, or even wrong; but they guide perception and initiate understanding. At birth or shortly thereafter, knowledge structures in some form are available for our use and refinement.

Human learning is a matter of strengthening internal knowledge structures. As one becomes engaged in experiences, his or her existing knowledge structures are activated. These existing structures, as a result of the new experience, can become more complex with more connections; they can become altered to accommodate a new understanding; or they can become obsolete because the new experience has caused the creation of a new knowledge structure. This sifting and winnowing of prior knowledge structures constitutes learning.

Constructivist Teaching Practice

Constructivist teaching is guided by the previous six theory statements. It can take many forms; but whatever its form, it must help learners construct their own knowledge. It must help learners focus on what they currently know, be receptive to new information, fit the new information into the current knowledge structure or revise the current knowledge structure, and become aware of what they know and know how to do.

The following elements constitute one conception of constructivist teaching. These elements are equally applicable to teaching declarative knowledge — such as substantive facts, concepts, and generalizations — and procedural knowledge — such as skills, processes, and techniques.

Five Basic Elements

Activating prior knowledge. Since what is learned is always learned in relation to what one already knows, to one's existing knowledge structure, it is important that this prior knowledge be identified. Students and teachers need to be aware of students' knowledge structures, because these structures accommodate the new experience and guide the perception of the new experience. When students are aware of their prior knowledge, they can appreciate their vantage point and more readily decide if the new content fits into an existing structure or if a new structure is required. When teachers are familiar with students' prior

understandings, they can better plan and provide learning experiences that build on these existing understandings. Or, if the existing understandings are faulty, if they constitute misconceptions, then the teacher can engage students in activities to change these misconceptions before proceeding with the new content.

Prior knowledge can be activated in many ways. Simply asking students what they know about the topic to be studied can be effective. But sometimes a less direct technique is more productive in drawing out what they know. Other procedures that can reveal students' prior knowledge include brainstorming the elements of some phenomenon or the causes of some event (such as brainstorming the planets and other aspects of the solar system prior to studying the origin of the solar system), creating a timeline of events leading up to the topic of study (such as U.S. military conflicts prior to Vietnam), and predicting the consequences of a demonstration or experiment (such as hypothesizing the effects of various environmental conditions on plant growth in advance of a study of photosynthesis).

Also, if the knowledge to be acquired is procedural knowledge, the teacher can have the students attempt to perform the actual skill, process, or procedure prior to instruction. Trying to plot two variables on a graph or write a persuasive essay can provide helpful information for subsequent instruction.

Acquiring knowledge. Students must encounter knowledge in a way that helps them determine the extent to which it fits their existing knowledge structures. The teacher needs to focus on *wholes* and to assist students in acquiring them. If students are to develop understanding, they need to see the "big picture" and its related parts. Understanding does not result when content is experienced as isolated bits of information. It does not result when depth is sacrificed for breadth and the coverage of prescribed amounts of subject matter. Focusing on wholes means to identify a few major ideas and to make them the center of instruction.

In declarative knowledge, wholes are concepts or generalizations and their related, interconnected facts. An idea — for example, that in

industrialized societies the functions that less-developed societies carry out in families are performed by institutions — is a whole. Its related parts might consist of the functions of education, medical care, manufacturing, government, and transportation. Another example is the idea that plants and animals exist in a symbiotic relationship. The supporting facts for this whole would consist of animals' need for food, shelter, and protection and plants' need for fertilizer, dispersion of seeds, nurturing, and so on.

In procedural knowledge, wholes are the complete skill or process and the sequential steps that compose it. An example is learning to square dance. Rather than painstakingly learning each step, body position, rhythm, and dance configuration and then putting them together to experience the dance, the constructivist teacher would show students the dance as practiced by competent dancers. The teacher also might have students attempt to perform the dance in a rudimentary way. Only after some sense of the whole is acquired would the parts that need attention be treated.

Teachers can assist students to acquire wholes and to fit them into their existing structures, or to use them as a springboard to alter structures or create new structures, in two ways: 1) They can arrange experiences and environments so that students come to see wholes and their parts, to see relationships and connections, or 2) they can directly present wholes and parts through lectures, demonstrations, and dialogue.

The type of assistance that constructivist teachers provide has been termed "scaffolding" (Collins, Brown, and Neuman 1990; Rosenshine and Meister 1992). The scaffolding metaphor points to the notion that a building is standing in some form, but it cannot stand alone. It needs support until it is strengthened by the addition of bricks, mortar, and steel. Some buildings, because they are defective, need to be razed before they can be rebuilt into a sturdy structure. Scaffolding with students can take many forms, but it always builds on students' prior knowledge. In learning both declarative and procedural knowledge, it

can consist of explanations, examples, analogies, manipulatives, graphic organizers, models, and answering questions. As students begin to acquire knowledge, the scaffold is withdrawn gradually until the "building" is standing on its own. That is, the teacher's help is no longer needed after the students have reached a state of cognitive equilibrium.

An example of scaffolding with an analogy occurred in a chemistry class. The topic was the electronic structure of atoms, the understanding of which is a prerequisite to understanding other chemical behavior. The students were asked to think about each electron as having a house address. Since each electron has four quantum numbers and no two electrons can have the same set of quantum numbers, quantum numbers are analogous to house numbers and can be used to locate or identify. By considering quantum numbers as house numbers, students were better able to understand quantum theory without a rigorous mathematical treatment.

Modeling, as an example of scaffolding, was used by a reading teacher to teach summarizing. The teacher summarized a passage read by the class. After the teacher summarized the passage, she analyzed her summary, showing how she eliminated trivial and redundant material, used global terms to classify more specific elements, and selected or invented topic sentences for each paragraph. As students attempted to summarize other passages, the teacher modeled summarizing if they had difficulty.

Understanding knowledge. Once students have been exposed to new content or skills, the process of understanding begins. The student compares the new information to his or her existing structure to determine if it fits into the structure and strengthens it or if it clashes with the structure and the structure needs to be altered. Teachers can assist the development of understanding by providing experiences that cause students to explore thoroughly the new content and to share their interpretations of the new content as it relates to their knowledge structures. Marzano states that "the most effective learning occurs when we continually cycle through information, challenging it, refining it" (1992, p. 67).

To thoroughly explore the content means to examine it carefully from both the inside and the outside in an effort to come to know its fine points. An inside exploration includes summarizing the content, paraphrasing its main ideas, reordering its parts, explaining its meaning, and defining its terms. An outside exploration includes comparing and contrasting it with other content, studying examples of it, creating analogies for it, extending it into new areas, evaluating it in relation to established standards, and classifying it into existing categories.

An inside approach that was used in a fourth-grade science class consisted of building a semantic map of terms associated with tornadoes as a way of summarizing a lesson on tornadoes. Another example might be having students compose a letter to Nelson Mandela, listing major questions they would like to ask him about the future of South Africa. This would be a follow-up activity after reading about and discussing South Africa and its problems.

Examples of increasing understanding from the outside are having students classify artists by style or period following several class sessions on famous artists and having students compare du Maurier's novella, *The Birds*, which they had been studying, with the Hitchcock film of the same name.

Sharing emerging knowledge structures is essential for understanding. When knowledge structures are displayed, others can react to them. They can provide perceptions and insights that cause the student to rethink his or her knowledge structure. Furthermore, those who are providing the critique cannot help but reconsider their knowledge structures as they hear and react to the structures that are being presented.

There are many ways in which knowledge structures can be shared and critiqued in the classroom. Dialogue between the teacher and students or among students in small groups in which students take turns voicing their interpretations, explanations, solutions, perceptions, and ideas can be effective in revealing developing knowledge structures. Other ways in which reasoning is made public in the classroom include oral reports, debates, role playing, demonstrations, simulations, and

displays. However, each of these activities must be accompanied by critique. It is the critique that causes students to rethink their positions and either modify or confirm them, and thereby strengthen them. Perkinson (1993) sees critical feedback as the most important aspect of teaching for understanding.

Following is an example of sharing ideas that took place through a simulation activity. In a unit on wildlife conservation, after the class had acquired knowledge about wildlife management and engaged in activities to deepen their understanding, the teacher involved the class in simulating the management of a moose population over a nine-year span. The factors that influence moose herd size, such as weather conditions, forms of habitat destruction, community education activities, and reproduction formulae, were written on cards. The students, assuming the roles of wildlife managers, rangers, and statisticians, selected cards and indicated the decisions they would make regarding the herd in relation to the information on the card. As the class discussed the responses to the cards, students' understandings were tested in the public arena of the classroom. Their understandings about the effects of human invasion on wildlife habitat, reproductive habits of animal populations, the delicate balance of natural communities, and other understandings emerged and were made clearer.

Using knowledge. Providing activities for students in which they use the knowledge that they possess, and about which they are beginning to develop understanding, extends and refines their understanding.

The most effective activities for knowledge use are problem-solving activities that are *authentic*, *interesting*, *holistic*, *long-term*, and *social*. Activities that require students to engage in solving problems result in making knowledge functional. Students must synthesize and operationalize their knowledge as they attempt to solve the problem. This process causes them to continue to examine and build their knowledge structures.

Authentic problems are those that are likely to occur in the real world, although they can be either academic or practical. They can be the type of problem that a historian or a scientist might face, or they can be the type that occurs in day-to-day living, such as planning a meal or developing a budget. *Interest* is critically important if students are to extend their understanding through activity, because if they are not interested in the activity, they will not participate to a sufficient extent. Activities that are interesting to students are those that involve contrast or emotional intensity, according to Sylvester and Cho (1992). An activity that provides contrast is one that contains some surprising, unexpected, or incongruous elements, while an activity that is emotionally intense is usually one that deals with life themes, such as love, violence, money, and death.

A *holistic* activity is one that is broad and multifaceted and has not been unduly simplified or shaped for pedagogical purposes. For students to test and strengthen their understanding, they need experiences that challenge their knowledge structures. *Long-term* means that the activity will occupy students for several periods or days. A short activity may not engage students long enough for them to rethink their knowledge structures. Finally, all other things being equal, a *social* activity is more useful than a solitary one. When students work in groups to solve a problem, they have the opportunity to constantly voice ideas and receive feedback on their adequacy.

Many activities can cause students to use knowledge, such as construction projects, research papers, proposals for action, data-gathering investigations, decision-making tasks, policy development, and many others. Whatever the form, an activity can be conceived, organized, and experienced as a *convergent* activity or a *divergent* activity.

A *convergent* activity is one that has one or more known outcomes. The teacher arranges and influences the activity so that the students arrive at the predetermined answer or product. Often these predetermined outcomes will be various collective constructions that scholars have developed and accepted over a long period of time; they will be

the basic concepts and processes of the disciplines. Constructivism comes into play as the students use their knowledge structures to arrive at these outcomes and alter their knowledge structure to accommodate the collective constructions that emerge.

A *divergent* activity, in contrast, is one in which the substantive outcomes are unknown. The teacher encourages original, creative outcomes. The students may build on collective constructions, but they produce their own, unique conclusions.

An example of a convergent activity from a secondary school mathematics class involved determining odds. The students computed odds for a set of state lottery games that varied by task and pool numbers. An example of a divergent activity is a second-grade project in which students — with the help of their parents — constructed a square for a class quilt that depicted a family tradition. The quilt was part of a home and family unit. Another divergent example is a middle school history activity in which students created magazines as they might have been written in 1945. This was the final task of a unit about World War II. In the odds activity only one outcome was possible, but in the other two activities students could create their own quilt squares and magazines.

Reflecting on knowledge. Students acquire knowledge, they deepen their understanding of it, and they use it in problem-solving situations. But if knowledge is to be fully understood and widely applicable in and out of school, they need to decontextualize it. This requires reflection.

Reflection refers to understanding what one knows, or metacognition. It is one thing to use knowledge to solve a problem, but it is another to become aware of the strategy one employed that led to the solution. Being aware of one's own knowledge results in self-control and autonomous behavior. It permits students to set goals and make plans to achieve them.

Activities that cause students to reflect are those that require them to step outside themselves and look back at what they have done. Such

monitoring and assessment can take place in many ways. Journal writing is an especially good technique for stimulating metacognition. It brings to the surface understandings that often are relegated to the background during the heat of problem solving. Teaching what one knows to others also is an effective means for causing reflection. It demands careful consideration of what one knows so that it can be presented in an efficient and effective way.

Another useful activity is simulation or role-playing. This activity requires students to examine their actual behavior as they engage in hypothetical, analogous situations. Any planning or proposal writing, such as planning a field trip or proposing a policy regarding school lunch, also causes reflection and self-regulation. Comparing one's processes and understandings with those of others also is a good way to stimulate reflection, according to Collins, Brown, and Neuman (1990).

In addition to these and other techniques in which students are actively involved in performing a task, reflection on one's own understanding and behavior can occur as one watches another engage in reflection. The modeling of reflection by the teacher or another student can cause students to do their own reflecting.

The five basic elements of constructivist teaching are not as discrete in practice as they have been presented here. In classrooms the elements are commingled in many ways. Some reflecting tasks may occur during the acquiring of knowledge; prior knowledge may be activated at many points in the lessons; more acquiring of knowledge may be provided following the use of knowledge; and so on. Nevertheless, the order in which the elements have been portrayed represents a general style or pattern of teaching that teachers can and do use.

Four Types of Constructivist Teaching

The four types of constructivist teaching that emerge from these five elements are application, discovery, extension, and invention. The

dimensions on which these types vary are *goal* and *order* as can be seen in Figure 1.

	Goals	
Order	Convergent	Divergent
Logical	Type 1: Application	Type 3: Extention
Psychological	Type 2: Discovery	Type 4: Invention

Figure 1: Types and dimensions of constructivist teaching.

Goal refers to the outcome the teacher is trying to achieve. It can be either a convergent outcome or a divergent outcome. Convergence, as previously defined, refers to a focus on predetermined ends, while divergence refers to novel, original outcomes. *Order* refers to the kind of lesson organization the teacher is using. The lesson can be organized in a logical way, in which activities that develop basic learning precede activities that promote more advanced learning. Or the lesson can be organized in a psychological way, in which activities may contain both basic and advanced learning. A psychological structure permits students to acquire knowledge in a way and at a time that is meaningful for them.

An examination of the four types of constructivist teaching along with an example of each type follows.

Application. The sequence of elements in application is the one that already has been discussed. The teacher begins by activating prior knowledge, then having students acquire some content or skill. Next, the teacher moves to activities designed to increase understanding. Then the teacher has students engage in a use activity and, finally, employs procedures that cause students to reflect on what they have

learned. The use activity in this type of teaching is a convergent one that causes students to directly apply what they have learned.

A second-grade language lesson exemplifies application. In this lesson the teacher sought to develop understanding of folktales. The lesson began with the teacher eliciting students' favorite characters from stories with which they were familiar and asking them to tell why the characters were their favorites.

Names that were mentioned included Charlotte, Pippy Longstocking, Lyle Crocodile, and Amelia Bedelia. Students said that these characters possessed such qualities as "funny," "smart," "like me," and "tough." Following this introduction, the teacher announced that the story for the day was "Anansi the Spider," a folktale from Africa. Before reading the story, the teacher had the class examine the pictures in the book and tell what they thought the story would be about.

After the story had been read, the teacher asked students to summarize the story, to ask questions of each other to check their understanding of the story, and to make predictions about what might happen next if the story were to continue. As this dialogue, which focused mostly on the events of the story, drew to an end, the teacher then asked students to describe the kind of character that Anansi is and to speculate on why he is considered to be a folk character. They indicated that they saw him as tricky, clever, and smart but also lazy and vain. A folk character, they concluded after the teacher synthesized and rephrased the students' comments, was the central figure in a folktale, a story that has no known author but has been handed down from one generation to another by a particular group of people. The folk character often represents the kind of figure that the group of people see as a hero, but can also have qualities that they do not admire.

Next the teacher asked students to choose a partner and assigned them the task of writing another version of the folktale featuring Anansi without changing the basic facts of the story. She explained that because folktales are handed down over time, slightly different versions of the same story often exist.

In later sessions these stories were shared, and the teacher asked students to record in their journals a definition of the term *folktale* and to describe a family folktale that might have been told and retold in their family.

This lesson on folktales fits the constructivist teaching application model. It begins with the teacher eliciting students' prior experiences with favorite story characters that can later be tied to folktales. The reading of the story represents the acquiring phase, and the dialogue following the reading deepens comprehension during the understanding phase. The process used here — dialogue relating to summarizing, clarifying, and predicting — is similar to what Palincsar and Brown (1984) describe as reciprocal teaching. The writing of additional versions of the folktale is the use phase, and the journal entry serves as the reflection phase. Although the use activity requires some creativity on the part of students, it is mostly convergent because the teacher is seeking only slight variations in the original story.

Discovery. The beginning point for discovery teaching is a use activity. Students engage in an activity that has been planned so that student involvement leads to a predetermined end. As students engage in the activity, they either acquire and understand the intended content or skills incidentally, as a by product of the activity, or the teacher provides experiences during the activity that foster acquisition and understanding incrementally. After the activity, other tasks may be done that enlarge students' understanding. The sequence is then ended with attention to reflection on the new learning that emerged.

Constructivist discovery teaching is illustrated by a fourth-grade science lesson on electricity. The objective of the lesson was to have students understand that static electricity results from negatively charged particles attracting uncharged particles. The lesson began with the teacher dividing the class into five groups and distributing a balloon, a piece of wool cloth, and a piece of graph paper to each group. She announced that the groups were going to explore static electricity by rubbing the balloon with the wool cloth and trying to make the balloon

stick to the wall. They were to vary the rubbing time, measure the balloon rubbing time and balloon adhesion time, and record their findings on the graph paper. As the groups began to work, she elicited students' experiences with static electricity.

Following their responses concerning "shocks" on cold days, clothes that cling when they first come out of the dryer, and lightning, and after much experimenting with the balloon and wool cloth, the teacher distributed pieces of cotton cloth and aluminum foil. She told the groups to continue their experimentation and to record the results. She also suggested that they try to make the balloon stick to a door, a window, and other surfaces.

After the groups had experimented for 20 minutes, she had the whole class share their findings. The students presented their data about static electricity production. The teacher then posed the question that several students had begun to ask: How does static electricity work? Responses included the ideas that rubbing warmed up the balloon, made the balloon shiny, cleaned off dust, and created friction. However, some students thought it had to do with positive and negative charges. The teacher built on this response and finally explained about atoms and electrons.

Next, the teacher had the class read a portion of the science textbook dealing with static electricity. A discussion followed in which misunderstandings were clarified and static electricity was compared to current electricity.

The last activity of the session was having students write in their science journals. They were to summarize their understanding of static electricity and propose a plan for the most efficient and effective way to pick up spilled pepper using a balloon.

This lesson is a good example of constructivist discovery teaching because the teacher began with a use activity and had one outcome in mind that she wanted students to acquire. The balloon-rubbing activities provided a hands-on experience that the teacher could use to introduce the explanation of static electricity. During the early phases of the group activity, she also activated prior knowledge; the later part of

the lesson, when she presented the explanation of what students were observing, was the acquiring phase.

Reading and discussing the textbook clarified the concept of static electricity; that was the understanding phase of the lesson. The journal entry, the last activity of the session, was the reflective phase. Summarizing of the major understandings and solving the pepper problem contributed to metacognition.

Extension. Extension teaching is similar to application teaching with one important difference. The use activity is divergent, rather than convergent. The teacher begins with acquiring and understanding tasks, but they are seen as being preparatory to the activity that follows, rather than as the center of the lesson. They provide the basic knowledge on which students can draw as they attempt to solve a problem that the teacher presents or that the students identify for themselves. The problem requires them to put the basic knowledge together in novel ways and to go beyond the acquired new information. After the divergent activity is finished, the teacher provides for reflection.

Constructivist extension teaching is exemplified in a middle school social studies lesson. In this lesson the teacher's objectives were to have the students learn the characteristics of a third-world country and to speculate on why third-world countries exist and how they can move out of third-world status. The lesson began with a review of the characteristics of developed countries. The teacher and students together identified the characteristics that the teacher wrote on the chalkboard:

1. Most people live in towns and cities.
2. Pay is high and hours of work are few.
3. Machines do most of the work.
4. Enough food exists for all.
5. Life expectancy is long.
6. Medical care is available to all.
7. Most adults can read and write.
8. People have money and time for leisure.

9. Houses have running water and electricity.

When the class was satisfied with the list, the teacher moved on to the third-world countries. First, he asked if anyone had seen a travel program on television about a country that might be a third-world or "under-developed" country. Responses included India, Zaire, Somalia, and Mexico. After students shared their knowledge of these countries, the teacher led a discussion in which he proposed and elicited characteristics of third-world countries. Seven characteristics emerged that also were listed on the chalkboard:

1. Natural resources are not fully used.
2. Much work is done by hand.
3. Most products must be imported.
4. Many people are farmers.
5. There is a great dependence on one crop.
6. Many people are illiterate.
7. The population is growing rapidly.

Next, the teacher distributed written descriptions of four fictitious countries for which various characteristics and statistics were identified. The students were to read the descriptions and decide if each country was more first-world or more third-world. After sharing and justifying their responses, several students volunteered additional characteristics of third-world countries. Three new items were added to the list:

8. Urban centers are overcrowded.
9. Housing is substandard.
10. Education is available to only a few.

Following this activity, the teacher initiated a group activity. Each of five groups was to identify a third-world country of interest; obtain economic, political, geographic, historic, and other information about the country; and try to explain why the country had not become de-

veloped and what it might reasonably do to become a more developed country. These investigations, which took several days to complete, resulted in reports shared with the total class on India, Cuba, Zaire, Somalia, and China.

The last activity was a class discussion on what each group did as it attempted to complete its task. The discussion focused on organizing and identifying goals, locating resources, developing and supporting arguments, and other matters.

The various aspects of extension teaching are apparent in this lesson. The review of previously acquired information about first- and third-world countries activated prior knowledge. The brainstorming and proposing of characteristics was the acquiring phase. The understanding phase was the activity in which the students compared and contrasted the characteristics of first- and third-world countries as they categorized the four fictitious countries. The group activity was the use element; here the students were engaged in a divergent task that required them to draw on and creatively use their knowledge of third-world countries. Reflection occurred as the class shared how they proceeded to investigate their actual third-world countries.

Invention. Just as in discovery teaching, the lesson begins with a use activity in invention teaching. But here the activity requires divergent thinking. The students encounter and try to solve a problem that has many possible answers, rather than one or more absolute answers. In working on the problem, the students acquire and come to understand content and skills that are needed to reach and support a solution. If an impasse is reached, the teacher may provide experiences so that students can continue toward solution. In invention teaching, as in discovery teaching, the elements usually are not separate or, indeed, separable. Again, the final part of the sequence should promote reflection.

A secondary school geometry lesson illustrates constructivist invention teaching. The teacher's intention in this lesson was for students to manipulate squares and to develop mathematical rules based on their

observations. The teacher divided the class into four groups and gave each grid-lined paper, scissors, and rulers. They were asked to cut out squares of various sizes and arrange them in various ways in order to produce rules or laws regarding squares. Near the end of the class period, the groups were to report to the whole class about the rules they had developed, including an informal proof for each rule.

Each group cut out square units and manipulated the squares as the teacher moved from group to group offering assistance and raising questions. One group cut out two 5 x 5 squares and then cut each large square into 25 smaller squares. Then they found that the smaller squares could be reconstituted into a 50-square unit. They discovered that the side of the new, large square had a length equal to 5 times the square root of 2. The rule they composed was that the sums of the areas of 2 squares is itself a square, and the side of the new, large square has a length equal to the length of the small square multiplied by the square root of 2.

Another group measured the sides and diagonals of squares and found that the ratio of the side of a square to the diagonal of a square is always 7:5. In dialogue with the teacher, the group came up with the rule that the diagonal of a square is the square root of 2 multiplied by the length of a side, because the square root of 2 is approximately 1.4, or the product of 7 divided by 5.

A third group focused on areas and observed that the sum of the areas of a 3 x 3 square and a 4 x 4 square equals the area of a 5 x 5 square. That is, 9 squares plus 16 squares equals 25 squares. In response to the teacher's encouragement, the group also came up with 5 x 5 plus 12 x 12 equals 13 x 13 and 6 x 6 plus 8 x 8 equals 10 x 10. This group was unable to develop a generalization (rule) about area before the allotted time expired.

The fourth group maneuvered squares around the table in various ways and observed that three squares could be put together in such a way that an empty triangle is formed in the middle. One of their configurations resulted in a right triangle being formed in the middle. The

rule they composed was that every triple set of squares in which the two smaller squares have a total area equal to the area of the largest square always forms a right triangle. When the teacher got to the group and read their rule, he asked them if it could be restated in terms of the right triangle. Their restatement (after several discarded attempts) was that the sum of the squares of the measures of the two shorter sides of any right triangle equals the measure of the largest side. Although discovering the Pythagorean Theorem was not the teacher's purpose, he did introduce the terms *legs* and *hypotenuse* and told them what they had produced.

In the reporting session that followed the activity, the three groups that generated rules presented and illustrated them. The remaining group shared its observations. Because this fourth group had not come up with a rule, the teacher asked the total class to try to compose a rule to fit the observations and to share it during the next class period. Also during the reporting session, the teacher asked questions about how the students arrived at their laws. He asked how they resolved false attempts, how they tested the law on additional observations, how they went about actually stating the law, and similar questions.

Although the constructivist teaching elements are not as evident in this example as in some of the other types of constructivist teaching, they were present in this invention lesson. The group activity involving squares was the use phase, but the acquiring and understanding phases were embedded in it. The use activity qualifies as invention because the students were free to create and manipulate squares in any way they chose and to develop whatever rules seemed to emerge. The teacher did not have specific mathematical rules that he intended would emerge or that he steered the groups toward. The fact that one group discovered the Pythagorean Theorem was coincidental.

However, it is true that in mathematics the rules that the students could possibly develop have undoubtedly already been formulated (perhaps in slightly different terms), while in another content area such as social studies or literature there is more opportunity for novel and

extensive divergence. The acquiring and understanding phases occurred as the teacher monitored the activity of the groups. Through statements, questions, suggested rearrangement of the squares, challenging drafts of the rules, scaffolding first rule attempts, and other ways, the teacher provided information and helped students to understand it. Some drawing on prior experience also was exhibited during the monitoring process.

The last activity of the class, the reports with accompanying dialogue, constituted the reflection phase and contributed to metacognition.

The four types of constructivist teaching are not always as simple and straightforward as these examples. The cycle of the five elements is not always completed in one or two class periods; several cycles of one or more types can occur in one lesson; and abortive and partial cycles can occur.

Furthermore, the four types of constructivist teaching are not four parallel, equally constructive types; they represent a range of constructivist teaching based on the ends one wishes to achieve and the means that one prefers to use. All teachers can and probably would use all four types as they teach their students, but some types may fit a particular teacher better than others. The next section explores how to decide which types are a better fit and therefore have a greater chance of being used effectively.

Constructing Constructivist Teaching

Deciding about constructivist teaching, or deciding about any instructional procedure, is a matter of examining possible instructional methods to determine which are consistent with one's beliefs. Research and theory are helpful in identifying ways to teach. But teachers need to decide for themselves which techniques they will and will not use. When reduced to their essential character, these decisions deal with beliefs about students, their human qualities and learning processes, and with beliefs about knowledge, its form and function.

If the beliefs about students and knowledge embedded in the technique or practice match the beliefs the teacher has about students and knowledge, the technique will be one that fits the teacher. In order to make decisions about constructivist teaching, two views of students and two views of knowledge are especially important.

One view of students is an active view. From this perspective, students are autonomous, can decide for themselves, wish to explore, and take responsibility for their behavior. They have the ability and desire to act on their own. They will enter into, plan, and pursue a task to a satisfactory conclusion.

A contrasting view of students is the reactive view. In this view students seek direction, benefit from guidance, need to be stimulated, require organization, and want explicit limits. Rather than act on their own volition, they prefer to respond to an external structure. They benefit from logical sequence and from models and systematic coaching.

Of the two views of knowledge, one is the personal view. Significant knowledge from this perspective is the knowledge that students make for themselves. An understanding of major concepts and processes is important, of course; but this view of knowledge suggests that students' individual interpretations that result from creative and critical thinking are of greater importance. Here the goal of school is to have students reconceptualize existing structures and create new structures.

The other view of knowledge is the foundational view. Foundational knowledge consists of those powerful, collective constructions that have been developed over time through sharing, critiquing, and revising. This is the knowledge of experts in the various disciplines. The goal of schools, from this position, is to have students acquire this foundational knowledge and fit it into their existing knowledge structures or adjust their structures to accommodate it.

These views of students and knowledge represent reference points rather than dichotomous positions. Instead of believing one position to the exclusion of the other, most teachers probably support both positions on each variable to some extent, but they believe one more than the other. Beliefs are a matter of degree.

The direction toward which one leans in regard to the views of students and knowledge suggests which type of constructivist teaching may be appropriate for the particular teacher. Given the two belief variables and the two possible positions on each, four major belief patterns are possible: 1) reactive students and foundational knowledge, 2) active students and foundational knowledge, 3) reactive students and personal knowledge, and 4) active students and personal knowledge.

If one believes that students are mostly reactive and that foundational knowledge is more important than personal knowledge, the teacher may prefer application teaching. The logical order of starting with activating knowledge and progressing toward use and finally reflection says that students need organization, guidance, and models prior to using their knowledge. That the use is convergent suggests that important knowledge is the foundational, collectively constructed knowledge of experts.

If one believes the opposite, that students are generally active and that personal knowledge is more important than foundational knowledge, then the teacher probably will prefer invention teaching. Beginning teaching with a use activity that either includes the other elements or serves as an occasion for their later use is an indication that students are perceived as active individuals who can decide and act for themselves. The focus on divergent outcomes in the use activity shows that personal knowledge is valued.

Of the two remaining belief patterns, one is consistent with discovery teaching and the other is consistent with extension teaching. If a teacher believes in active students and foundational knowledge, he or she will likely be drawn to discovery teaching. In discovery teaching the lesson starts with a use activity, which reflects the view that students can make many decisions themselves, but the use activity is structured in such a way that students converge on predetermined ends.

If one believes in reactive students and personal knowledge, he or she will probably prefer extension teaching, which calls for a lesson in which preparatory information is acquired before students engage in a use activity, but the use activity is one that requires divergence through creative and critical thinking.

A case might be made for the proposition that, because of the beliefs about students and knowledge that underlie each type, invention teaching is the most constructivistic, application teaching is the least constructivistic, and discovery and extension teaching occupy middle positions with regard to constructivism. Certainly more constructivism may be occurring in invention teaching, where students develop personal knowledge on their own, or in extension teaching, where personal knowledge is the ultimate goal; but constructivism also is occurring to varying degrees in the other two types of teaching. If the focus of application teaching and discovery teaching were not an understanding of collective constructions complete with an emphasis on prior knowledge and reflection (and the metacognition it produces), then constructivism may not result — but that is not the case.

In deciding which form of constructivist teaching to use, beliefs are of major importance. But they are not the only basis for deciding. Because of one's beliefs, the teacher is likely to prefer, and therefore to use, those techniques that are consistent with the beliefs. However, classroom demands will require that a range of techniques be employed. Students' ability and experience, as well as the subject and particular content or skill to be taught, will influence the type of constructivist teaching that is most appropriate at any given moment.

36

Threats to Implementing Constructivist Teaching

Regardless of the types of constructivist teaching a teacher may choose, the classroom setting contains potential threats to implementation that must be reduced or eliminated if implementation is to occur. Three major threats or constraints are student expectations, content coverage, and evaluation.

Student Expectations. The student's role in constructivist teaching is to willingly engage in activities; share thoughts in dialogue, journals, and other ways; pursue topics in depth; critique other students' ideas; cooperate in group tasks; and create meaning. Hands-on activities, cooperative learning, journal writing, and other procedures that are compatible with constructivism exist in some form in many classrooms; but a full complement of constructivist teaching practices probably is missing in most classrooms. Students are accustomed to more teacher control and direction, an emphasis on correct answers, not expressing their thought processes, extensive practice of skills, and similar conventional classroom events.

An abrupt change in role from the traditional to the constructivist may be unrealistic. However, if the teacher incrementally substitutes constructivistic practices for traditional practices, then students may begin to assume this new role. Authentic tasks, valuing of students' ideas, building on their current level of understanding, and respecting

their judgments can encourage students to join in the process of constructing knowledge. Together these acts create a classroom climate of trust in which students will risk thinking for themselves and revealing their thoughts to others.

Content Coverage. In constructivist teaching, as in more conventional teaching, the content and processes that experts in the various disciplines have constructed over time are of central importance. However, in constructivist teaching, it is the students' careful interpretation and deep understanding of the content and processes — in contrast to the ability to reproduce them — that is of concern. Constructing knowledge by fitting new content into existing structures or by adjusting existing structures usually cannot be done quickly, nor can it be easily contained within arbitrary boundaries. Yet the content from curriculum guides and textbooks that teachers are expected to use consists of volumes of facts, concepts, and skills in separate subject areas. However, the expectation of content coverage in each of the subject areas need not preclude the use of constructivist teaching.

To achieve content coverage, the constructivist teacher needs to search his or her content area for the most powerful, generative ideas, as Bruner (1960) advised many years ago, and to make them the main objects of attention. These ideas undoubtedly will subsume a myriad of facts, which will result in a degree of content coverage. And because of their breadth, they flow into other content areas. The ideas cannot be construed nor presented as natural laws. Their tentative, socially constructed nature must be communicated. Textbooks and other learning materials in which the content is embedded must be viewed as "scaffolding on which readers can build their interpretation," according to von Glaserfeld (1992, p. 175).

Testing and Evaluation. Even as portfolio assessment is gaining a foothold in many classrooms, achievement tests still are prevalent. School districts typically use standardized achievement tests at various

grade levels, and state departments of education often require tests of various kinds to be administered in reading and other areas. Generally, these tests require students to reproduce on machine-scored forms the facts and abilities they have acquired. Their emerging knowledge structures and metacognitive skills are neither examined nor evaluated.

If one engages in constructivist teaching and learning, if one emphasizes thinking and understanding, lower test scores on standardized achievement tests are not inevitable. On the contrary, it is reasonable to believe that if one has deep understanding of a concept or skill, he or she should score well on a test — even though the test emphasizes recall of facts or display of skill segments.

However, the question of actually evaluating constructivist thinking remains. Portfolio assessment, in which students and teachers can see and reflect on progress over time, is a step in the right direction if the focus is on interpretation and understanding. Problem-solving "tests," in which students are required to extend and reconceptualize their knowledge in new contexts, also are a possibility. Observing how students approach the problem can reveal the present state of their knowledge structures.

Other threats to implementation, such as class periods that are too short for extensive thought, supervision practices that reward more nonconstructivist teaching, school disciplinary practices that support a behaviorist ideology, and bulging class enrollments, all constrain constructivist teaching. But they do not prevent its use in some form for teachers who are persistent and creative.

Constructivist Teaching and the Future

Whether constructivist teaching is an education fad and soon will vanish or be relegated to a back bench except for a few tenacious zealots is unknown. It would seem that it might have a longer life than many education innovations because it is not just a technique whose value is judged by its ability to produce an immediate result. Constructivist teaching — unlike direct instruction, for example — is based on theory. It emerges from a cohesive set of ideas about knowledge and learning that have their roots in philosophy and psychology. The theory may become clearer, new elements may be created, and additional types may be developed; but the power of the ideas suggests that this way of teaching will be long-lived.

The question of whether to use constructivist teaching is in some ways inconsequential. Constructivism on the part of students, if we believe constructivist theory, is unavoidable. It will happen no matter what teachers do instructionally. Any and all student experiences result in student construction of knowledge. The issue, then, is whether we should let students construct on their own in spite of their classroom experiences or whether we should do whatever is in our power to encourage and facilitate constructivism through experiences specifically designed to promote the making of knowledge by students.

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